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The Impact of Institution Quality, Cluster Strength and TLO Licensing Capacity on the Rate of Academic Staff Spin-offs

Gil Avnimelech
Ono Academic College
Faculty of Business Administration
gilavn@gmail.com

Maryann Feldman

maryann.feldman@unc.edu

Abstract
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Abstract

This paper examines the spawning of new company founders' from 124 leading U.S. academic institutions, using a unique database. We examine both local and non-local spin-offs of academic staff members. Accordingly, the rate of spawning is positively affected by the institution quality, the strength of the local entrepreneurial cluster in the region where the institution is located, and the share of R&D expenditure financed by the federal government. On the other, hand the effectiveness of the university technology licensing office (measured by license revenues per R&D expenditure) has a negative impact on the rate of academic spawning. Moreover, we find evidence that after controlling for the entire institution rank, the rank of the business school has a positive and significant impact on the institution spawning rate. When comparing the local spin-offs to non-local spin-offs we find that while 42% of faculty spin-offs are created in the region of the academic institution. Not surprisingly, we find that local cluster strength and culture has very limited impact on non-local academic spin-offs. Moreover, institution R&D expenditure and sources of R&D finance has low impact on non-local academic spin-offs.

Keywords: *Entrepreneurship; Academic Spawning; New Firm Founders; Spin-off Firms; Regional Economic Development*

1. Introduction

In the current era academic institutions have multiplied mission from enhancing basic research and training skilled work force toward enhancing technology transfer through patent licensing and academic spawning of new innovative firms (Feldman, 2003). Therefore, boosting regional economic development based on strengthening local academic institutions and their technology transfer units is a well-accepted economic development strategy.

Innovative start-ups play a significant role in enhancing economic growth (Wennekers and Thurik, 1999). This paper will focus on spin-offs from academic institutions and their role in regional development.

Academic spin-offs appear to be an effective mean of technology transfer, leading to job creation and wealth creation (Rogers et al., 2003). Despite the growing literature on university role in technology transfer and regional economic development, there is still little systematic empirical evidence about the ability of academic institutions to spawn companies and the regional attachment of these academic spin-offs.

A common broad definition of academic entrepreneur is an academic scientist who sets up a business company in order to commercialize the results of his/her research (Franzoni and Lissoni 2009; Roberts and Malone, 1996; Smilor et al., 1990; and Steffenson et al., 1999). In this view, any scientist who developed inventions with commercial potential is a latent academic entrepreneur (Franzoni and Lissoni, 2009). The main question in this paper is: what are the institutional attributes that transfer these latent academic entrepreneurs into founders of academic spin-offs? And whether these spin-offs tend to stay in the local region?

This paper offers novel evidence about the spawning of founders' from 124 leading U.S. academic institutions, by past and present faculty members. We develop a unique database of founders with prior work experience in 124 leading U.S. academic institutions based on data collected from Linkedin, the online professional social networking tool. We examine the spawning of founders at both the regional and global contexts. We consider the academic spawning of entrepreneurs as a function of the local cluster characteristics, the ranking of the university and its leading faculties, the size and sources of the

R&D budget of the parent academic institution, and the institution's technology licensing office effectiveness (measured by licensing revenues per total R&D expenditure in the institution), after controlling for the size of the institution and it royalties share policy.

2. Literature review

2.1. University Technology Transfer

Scientific and technological knowledge is considered to be the most important raw material for economic development (Mowery and Rosenberg, 1989). The attention on the exploitation of such knowledge produced by academic institutions has increased in recent years (Chiesa and Piccaluga 2000). This dramatic increase in technology transfer efforts in the academia is attributed to several reasons: the emergences of biomedical research in the 1970’s, the passage of the Bayh-Dole act in 1980, increase of academic research sponsored by the industry, and a change in university attitude toward technology transfer (Mowery et al., 2004).

Several stages can be observed in the evolution of university technology transfer (Etzkowitz, 2002, 2003, 2010). In the 1980s, the *passive patenting format* was characterized by patenting in order to protect the university’s IP, without any significant marketing efforts. This stage of the university technology transfer strategy was a direct reaction to the Bayh-Dole act (Henderson, Jaffe, and Trajtenberg, 1998; Stevens, 2004). The *pro-active patent' marketing* format reflects the understanding that in order to leverage the university IP a pro-active search for potential users are required (Etzkowitz, 2010; Shane, 2004). As a result, since the early 1990s, many universities expended the scale and scope of their TLO activities. However, it soon became clear that in many cases, even with a pro-active patenting strategy, the licensing of potentially valuable patents was not easily achievable due to the early stage of the developments, the tacitness of the knowledge, and the risk profile of the inventions (Franzoni and Lissoni, 2009; Jensen and Thursby, 2001, 2002; Jensen et al., 2003; Thursby et al., 2001, 2005). Therefore, since the late 1990s a trend of enhancing technology transfer through academic spin-offs began (Doutriaux and Barker, 1995; Etzkowitz, 2010; Shane, 2004).

2.2. Academic spin-offs

Patent licensing has traditionally been the dominant route for the commercialization of technology invented at universities and research institutes but in the last two decades universities do increasingly consider the creation of spin-offs as a way of commercializing their internal research results (Chiese and Piccaluga, 2000; Clarysse et al., 2001a,b; Malone, 1996; Mustar, 1995, 1997, 2001; Roberts and Carayannis et al., 1998; Shane, 2004; Smilor et al., 1990; Steffenson et al., 1999; Thursby and Thursby, 2002, 2007). Since the late 1990s, academic spin-off, founded to exploit the university IP, have become an important economic phenomenon (Di Gregorio and Shane, 2003; Siegel, Veugelers and Wright, 2008). In addition, following the tremendous growth in venture capital finance and entrepreneurial activity since the mid 1990s, the financial investors' community has shown an increasing interest in academic spin-offs as investment opportunity (Clarysse and Moray, 2004).

According to the Association of University Technology Managers (AUTM) 3,376 spin-offs were created in the U.S. between 1980 and 2000 (AUTM 2001). In the last decade the academic spin-off rate accelerated with an average of more than 500 new start-ups each year, which is more than double than the average rate in the 1990s (AUTM, 2008). Roughly 16% of university' inventions are transferred to the private sector through the founding of spin-offs (AUTM, 2008).

Academic spin-offs have been shown as an important means of transferring technology from academia and enhancing the national economy. The following roles have been attributed to academic spin-offs: boosting economic activity and regional development (Di Gregorio and Shane,2003; Nicolaou and Birley,2003a; Roberts and Malone,1996; Mian, 1997), creating new wealth and new jobs (Perez Perez and Sanchez, 2003; Steffensen et al., 2000; Walter etal., 2006), providing a strong tie between industry and science (Debackere and Veugelers, 2005), and enhancing innovation and introduction of new commercial products to the marketplace (Varga, 1998).

2.2.1 Academic spin-off and regional development

Academic spin-offs may be an important mechanism for regional economic development (Di Gregorio and Shane, 2003). The well-known examples of new industrial cluster growth such as Silicon Valley in California, Route 128 in Massachusetts, and the Research Triangle area in North Carolina are all closely connected to major research universities, and this fact has been perceived as instrumental in positioning these regions on new, technology-intensive growth trajectories (Feldman, 2003). Goldman (1984) found that 72% of the high tech companies in the Boston area in the early 1980s were based on technologies originally developed at MIT laboratories. Thus, the Route 128 economic infrastructure might not have existed in the absence of MIT and its spin-offs, even though most of these spin-off companies were not based on formal technology licenses from MIT (Van De Velde, Clarysse and Wright 2008).

The location of academic spin-offs

Formal academic spin-offs appear be primarily local[1]. In 2000, 80% of firms formed from university licenses operated in the state where the university was located (AUTM, 2001). Zhang (2007) found that 78% of university spin-offs, which raised VC finance between 1991 and 2001, were located at the same state as their parent academic institution. Investigation of 72 spin-offs from MIT between 1980 and 1996 (Shane, 2004) reveal that 50% are located within 20 km of MIT and over 70% are located less than 100 km from MIT. Egeln, Gottschalk and Rammer (2004) find that 66% of academic spin-offs in Germany locate within 50 kilometers from their university. Astebro and Bazzazian (2010) argue that a dominant fraction of spin-offs are located extremely close to their parent, within 50 km (approximately 35 miles).

The literature presents several reasons way most of academic spin-offs are local. Often, an academic inventor will retain employment with the academic institution (Zucker, Darby and Brewer, 1998). Moreover, even when the founder leaves the university to form the spin-off; he may want to use the students and labs of the university to engage in additional research to support the spin-off (Hsu and Bernstein, 1997). Further, the inventor may want to exploit his local networks to support the spin-off. Finally, the inventor may prefer not to move a

[1] This paper will present evidence that many informal academic spin-offs are actually created outside the region of the parent institution.

household as such is costly both socially and economically (Dahl and Sorenson, 2007; Falck, Fritsch, and Heblich, 2008). However, moving may be useful if local conditions are not ideal for the spin-off (Egeln, Gottschalk, and Rammer, 2004). Moreover, for non-formal spin-off that exploit non formal university IP it may be better moving away from the parent institution, in order to reduce the attention of the institution and avoid conflict regarding the owner of the spin-off's IP.

Heterogeneity in the rate of academic spin-off

While academic spin-off became significant phenomena, its frequency varies significantly across different academic intuitions and different regions (Di Gregorio and Shane, 2003). Some universities, like MIT, routinely transfer their technology through the formation of new firms, while other universities, like Columbia University and Yeshiva University, rarely generate start-ups. Moreover, some regions enhance and support regional academic spin-offs such as Silicon Valley, Boston, and New York, while other regions has less developed entrepreneurial infrastructure such as East Lansing, Michigan or Providence, Rhode Island.

2.2.2. Non-formal academic spin-offs

While, Markman et al. (2008a) and Roberts and Eesley (2009) suggest that the real number of academic faculty spin-offs is actually at least twice as many as reported to AUTM, most research still focus only on formal academic spin-offs. Even when the importance of non-formal spin-offs is recognized the empirical investigations these spin-offs have been hindered by the lack of systematic data on founders who were previously employed by an academic institution.

This paper offers novel evidence about all spin-offs from academic institutions. We develop a unique database of founders who worked at 124 leading U.S. academic institutions based on data collected from LinkedIn.

2.3. Academic spinoff – explanatory variables

Di Gregorio and Shane (2003) argue that both micro and macro-level factors influence the decision to create a new start-up to exploit a university invention. At the micro-level, research has shown that the attributes of technological inventions themselves (Shane, 2001a), inventors' career experience (Levin and Stephan, 1991; Shane and Khurana, 2000), their psychological make-up (Roberts, 1991), and their research skills (Zucker et al., 1998) influence this decision. At the macro-level, research has shown that technology regimes (Shane, 2001b), the strength of patent protection in a specific technological area (Shane, 2002), and universities' IP and human resource policies (Lach and Schankerman, 2004, 2008; Goldfarb et al., 2001; Kenney, 1986) influence this decision.

This paper will focus only on the effect of the macro-level factors on the rate at which new firms are created to exploit university inventions. These factors vary across universities and regions. Following we will present these explanatory macro-level factors and their expected influence on academic spin-off rate.

Prior research suggests four macro-level explanations for cross-university variation in academic spin-off activity including: 1) the level of development and the entrepreneurial culture of the region surrounding the university and the volume of local venture capital activity, 2) the commercial orientation and sponsorship of university research, 3) university and departments intellectual reputation, and 4) university policies and incentives structure. We will add a fifth variable which is the TLO effectiveness measured by commercial output per million dollar R&D research (i.e. license revenues).

2.3.1 Established high tech cluster and local venture capital market.

The first argument for cross-university variation in spin-off activity is the development of the regional cluster. Certain cultures are less entrepreneurial than others. Innovative high tech firms seem to flourish especially in very particular regional clusters of which Silicon Valley and Boston area are the archetypes (Lee et al., 2000; Kenney, 2000; Saxenian, 1994). Therefore, while some regions significantly enhance academic spin-offs, other regions may depress academic spin-offs.

Location affects resources available to aid entrepreneurship and start-up development (Lechner and Dowling, 2003). The decision to start a new company, certainly, depends on local conditions such as access skilled human capital, the availability of local networks that mobilize the resources essential to founding a new firm (Sorenson, 2003; and Stuart and Sorenson, 2003a, 2003b), the strength of the entrepreneurial infrastructure (Thornton, 1999), entrepreneurial culture and tolerance for risk and entrepreneurial activity (Audretsch and Keilbach, 2004; Davidsson, 1995; George and Zahra, 2002; Lee et al., 2004; Mueller and Thomas, 2001; Thornton, 1999), and local availability of risk capital and other supportive services (Florida and Kenney, 1988; Saxenian, 1994; Sorenson and Stuart, 2001).

The empirical literature suggests that in contrast to the rate of academic spin-offs in established high tech clusters, academic spin-offs in regions outside such clusters are rare (European Commission, 1998, 2000. In general,

H1a: The more developed the cluster surrounding the university, the greater the rate of the university spawning. More specifically, the more entrepreneurial cluster surrounding the university, the greater the rate of the university spawning.

One characteristic of the local cluster - availability of venture capital in the area - has a significant impact on cross-university variation in spin-off activity (Carayannis et al., 1998). In-sufficient finance is regularly cited by nascent-entrepreneurs as a major barrier to starting a business (Volery et al., 1997; Kouriloff, 2000; Robertson et al., 2003; Choo and Wong, 2006). The finance and entrepreneurship literature have recognized venture capital as the main source of finance to entrepreneurship (Timmons and Bygrave, 1986; Gompers and Lerner, 1999).

Universities located in geographic areas rich in venture capital are more likely generate spin-offs due to several reasons. First, because venture capital is a major source of equity financing for new technology companies, its availability is important to overcoming capital market barriers to the financing of new technology firms (Gompers and Lerner, 1999). Second, in addition to providing capital, venture capitalists play an important role in the innovation process by providing valuable operating assistance to new high technology firms (Gompers and Lerner, 1999; Zucker et al., 1998). Third, venture capitalists serve as "market makers" for business development resources by connecting new technology companies with potential suppliers, customers, lawyers, manufacturers, and employees (Florida and Kenney, 1988). Finally venture capital investments tend to be made locally (Chen et al., 2010; Sorenson and Stuart, 2001; Zook, 2002).

Di Gregorio and Shane (2003) found no effect of local venture capital activity and local academic spin-off rate. Wright et al. (2007) found evidence that involvement of venture capitalists in university spin-offs facilitate their creation. Zhang (2007) found that the total venture capital investment within 50 miles is significantly and positively correlated with a university's number of academic entrepreneurs. Therefore we argue that:

H1b: The greater the availability of venture capital in the area, the greater the rate of the university spawning.

2.3.2. The scope and oriented research.

The second argument for cross-university variation in spin-off activity is the scope of the commercial orientation of university research. There is often a tension in the universities' mission between basic research and the search for ideas with potential commercial application (Wade, 1984). In many institutions the basic research is considered the legitimate function, while commercial activity is regarded as an inappropriate focus. This situation is reflected in the academic reward systems, in the share of industry sponsored research and in the institution policy toward technology transfer (Feldman, 2003). D'Este et al., (2010) found that encouragement of researchers toward commercial research by its institution has a positive and significant impact on both inventions disclosure and university spin-off rate.

Universities differ on the degree to which their researchers focus on industrial problems. Commercially-oriented universities receive more of their research budget from industry (Rosenberg and Nelson, 1994) and are more likely to make commercially-oriented discoveries and to generate spin-offs (O'Shea et al., 2005; Zucker et al., 1998; Powers and McDougall, 2005).

Blumenthal et al. (1996) found that industry funded faculty members are more commercially productive than those who are not industry funded. Di Gregorio and Shane (2003) found only limited support for the effect of the commercial orientation of university on its spin-off rates. Powers and McDougall (2005) found a positive and significant relationship between annual university commercial oriented R&D expenditure and spinoff activity. O'Shea et al., (2005) found that both the total R&D budget of the university and the portion of funding that comes from the industry have positive and statistically significant impact on the level of university spin-offs.

H2a: the greater the amount of research and development activity at the university, the greater the rate of spin-off activity.

H2b: the greater the share of commercially-oriented research activity financed by the industry at the university, the greater the rate of spin-off activity.

2.3.3. University Ranking & Reputation

The third argument for cross-university variation in spawning activity is university quality. Highly rated universities are more likely to generate spin-offs for two main reasons. First, high ranked schools are more likely to employ leading-edge researchers and such researchers are more likely to start firms to exploit their inventions. Therefore, spin-offs will be more common at highly ranked schools (O'Shea et al., 2005; Zucker et al., 1998; Powers and McDougall, 2005). Second, the university's reputation makes it easier for researchers to raise capital for their new venture. In addition, to the general intellectual ranking the specific ranking of business schools can influence the level of the academic spin-off activity (O'Shea, Allen, Chevalier, Roche, 2005). The ranking of the business school might be a proxy of the institution's orientation.

In a study of biotechnology IPOs, Stephan and Everhart (1998) found that the amount of funds raised and the initial stock evaluation of firms were positively associated with the reputation of the university-based scientist associated with the firm. Di Gregorio and Shane (2003) found that spin-off companies from top universities were more likely to attract venture capitals than those from less prestigious institutions. They also found that the university's ranking positively influences academic spin-off rates. Di Gregorio and Shane (2003) found that it is easier for academics from top tier universities to assemble resources to create start-ups due to their increased credibility. O'Shea et al., (2005) found that faculty quality has a positive and statistically significant impact on the level of university spin-off, while number of faculty and research student are not significant. This indicates that it is quality rather than quantity of human capital resources that matters in determining university spinoff activity. Zhang (2007) found that university's research quality is the most significant variable in explaining the number of academic entrepreneurs from a university.

H3a: The greater the ranking of the university, the greater the rate of spin-off activity.

H3b: The greater the ranking of the technological departments of the university, the greater the rate of spin-off activity.

H3c: The greater the ranking of the business school, the greater the rate of spin-off activity.

2.3.4. University policies.

The fourth argument for cross-university variation in spin-off activity is that universities differ in their policies toward technology transfer and that those policies shift activities at the margin toward or away from start-up activity.

The traditional literature on technology transfer from the academia focused on the TLO characteristics and the incentives structure to academic inventors. (Markman et al., 2008b; Belenzon and Schankerman, 2009; Lockett and Wright, 2005). The main argument is that universities that adopt certain policies and incentive structures could generate more spin-offs because those policies provide greater motivation for entrepreneurial activity by faculty members.

In particular, the distribution of royalties, between inventors and the institutions, was found to influence the propensity of entrepreneurs to found firms to exploit university inventions (Lach and Schankerman, 2004, 2008; Lockett, Siegel, Wright, and Ensley, 2005; Shane, 2004; Lockett and Wright, 2005). In this paper we do not focus on these issues, which were already subject to significant examinations and are independent of the issues we are focusing on. However, we do use the royalties share policy variable (Lach and Schankerman, 2004) as a control variable.

Complementarities between different technology transfer mechanisms

While the quality of the TLO is associated with higher levels financial rewards from technology transfer activities in general, it is not clear that it has the same effect on these different technology transfer instruments (patents, licensing, spin-offs creation, consulting and joint research agreements with the industry). The question of what instrument is best suited to transfer different pieces of knowledge has been the focus of many recent studies (Shane, 2004).

The decision of whether or not the exploitation of a technology is best achieved by patent licensing or by a start-up depends on the technological regime and on the appropriability of the innovation. In low-appropriability environments, licensing may be hard and innovations may not be commercialized because of a lack of incentives. However, if the knowledge is also characterized by high tacitness, the creation of a company exploiting a scientist's unique knowledge may become an effective instrument to realize the economic potential of the invention (Shane, 2004).

The decision on the instrument used to commercialize the innovation is also related to the professionalization of the TLO. When the TLO is professional and experience in proactive licensing marketing, the scientist might prefer to stay completely devoted to his academic work, without risking his potential economic reward. However, if the scientist believes that the TLO staff would not be able to commercialize his innovation, he might choose, against his natural preference, to create a startup to exploit his invention. In support of this view, Etzkowitz (2010) suggest that in the case of Stanford University the great financial success in licensing reduced the motivation of scientists to commercialize their research through spinoffs.

H4: After controlling for total R&D expenditure and royalties share policy, the greater the success in licensing of the university, the lower the rate of spin-off activity.

3. Data and Methodology

AUTM annually surveys university TLOs to obtain information related to patenting, licensing, and start-up firm activity. AUTM has collected data regarding university spin-off activity since 1994. However, Markman et al.

(2008a) suggest that the real number of academic spin-offs is actually twice as many as reported to AUTM. Moreover, Roberts and Eesley (2009) comprehensive report on MIT spin-off presented a clear picture that the number of spin-off reported by AUTM is an underestimation of faculty spin-offs.

Therefore, our dependent variables are counts of present and previous faculty members which founded new start-up companies, collected from Linkedin. We use two set of regressions for estimating local and global spin-off by faculty members. In our sample of 124 leading U.S. universities we have 12,799 faculty spin-offs compared with less than 7,500 spin-offs indicated in AUTM data in the last three decades (see AUTM 2001, 2009). Moreover, in our extended sample which includes the 305 institutions in the AUTM database we capture more than 22,000 faculty spin-offs (our sample is limited to 124 institutions due to limitation in the availability of other variables).

Dependent variable - founders' data

Data on founders was collected from *Linkedin*. This online social network profiles over 90 million members at January 2011. It is a professional network which includes more than 525,000 entrepreneurs worldwide and 300,000 entrepreneurs in the U.S. and almost 2,000,000 different companies (30% in the U.S.) from all sectors. Our sampling frame includes 124 academic institutions which reported to AUTM all the relevant information and that are ranked at the U.S. News rank of best national universities. We collected data on the individuals who had founded companies and were in the past or are currently faculty members of each of the 124 academic institutions in our sample.

Table 1: Faculty spin-offs - Descriptive Statistics

Dependent Variable	**Mean**	**%**	**Std.**	**Min**	**Max**
Local current and past faculty founders	43.12	42%	75.06	0	489
Non-local current and past faculty founders	60.10	58%	79.94	2	494
Total current and past faculty founders	103.22	100%	146.81	2	943

We rely on an innovative data collection procedure (see Avnimelech and Feldman, 2010a, 2010b). Each member in *Linkedin* provides a professional profile that includes present and past work experience. While there is always a chance that a member will present incorrect information, there is incentive to report correctly because each profile is verified by other *Linkedin* members. This transparency may yield data, which is more accurate than survey data[2].

Box 1 provides descriptive statistics for the dependent variables. Local spin-offs are defined as located within 35 mile radius from the parent institution. This is consistent with the finding about the radius of venture capital and business angel investments from their offices (see Lerner, 1995; Gompers and Lerner, 1999; Harrison and Mason, 1996, Wetzel, 1983). We can see that oppose to the common argument there are more non-local academic spin-offs than local ones. In our sample, 42% of the academic spin-offs are located in the region of the parent academic institution.

Box 1: Variables Description

Variable Name	Variable Description	Source
Non-Local Faculty Founders	Number of non-local founders spawned from a specific academic institution by past or present faculty members	Linkedin
Faculty Founders 35M	Number of founders spawned locally (35 mile) from a specific academic institution by past or present faculty members	Linkedin
FT_EQ	Count of full time equivalent faculty for 2008	IPEDS
Royalties Share	The share of equity the researcher receives from the license income.	Lach and Schankerman, 2004
R&D Expenditure	The total R&D expenditure (average 2003-2007)	AUTM
% Federal Government	The share of the R&D expenditure in the institution financed by the federal government	WebCaspar
% Industry	The share of the R&D expenditure in the institution financed by the industry	WebCaspar
% Local Government	The share of the R&D expenditure in the institution financed by the local government	WebCaspar
% Institution (omitted)	The share of the R&D expenditure in the institution financed by the institution itself	WebCaspar
Share R&D sponsored by Other sources	The share of the R&D expenditure in the institution financed by other sources (mostly non-for profit organizations)	WebCaspar
Total R&D Expenditure	The total R&D expenditure in U.S. dollars (average 2003-2007)	AUTM
Disclosures per R&D*	Number of invention disclosures (average 2003-2007) per 1M$ R&D expenditure	AUTM
Patents per R&D*	Number of patent applications (average 2003-2007) per 1M$ R&D expenditure	AUTM
License per R&D	Number of license agreement (average 2003-2007) per 1M$ R&D expenditure	AUTM
License' Revenues per R&D*	Total revenues granted from license (average 2003-2007) per 1M$ R&D expenditure	AUTM
Local VC Partners	Number of local VC partners located at the radius of 35 mile from the institution for 2010.	Linkedin
Cluster_35M	The count of entrepreneurs in the region (35 miles) of the institution (exploding spin-offs from the institution).	Linkedin
University Ranking (score)	The score of the entire institution (and of each department including engineering, computer science, medical and biotech)	U.S. News Report National Universities Rankings (2009)
Business Ranking (score)	The score of the business school	
Tech Ranking (score)	The average score of the engineering, medical, computer science, and biotechnology departments	

* Used only in the robustness tests.

[2] We conducted comprehensive robustness of entrepreneurs data presented in Linkedin (Avnimelech and Feldman, 2010a).

Independent variables

Data for independent variables were obtained from a variety of sources, including ATUM annual surveys, venture capital databases from the National Venture Capital Association (NVCA), the Integrated Postsecondary Education Data System (IPEDS) database, WebCaspar site and Lach and Schankerman (2004)[3]. Box 2 provides a summary of each variable and its source. Table 2 present the descriptive statistics of these variables.

Table 2: Descriptive statistics for the independent variables

Variable	Obs	Mean	Std. Dev.	Min	Max
FT_eq	124	6792.210	4526.649	104	23796
Royalities_Share	124	0.43	0.1332	0.20	0.97
Univ_score	124	42.234	29.237	0	100
MBA_score	124	27.524	34.792	0	100
Tech_score	124	32.012	25.168	0	93.25
Cluster_35	124	2702.202	5073.971	1	22035
VC_partners	124	98.903	208.913	0	1051
RD_exp	124	250M	247M	8.4M	1,520M
Licenses_Revenues Per R&D	124	0.042	0.148	0	1.47778
Share_federal	124	59.656	14.766	29	90.9
Share_local	124	7.738	7.999	0	43.8
Share_industry	124	6.264	6.359	0.3	48.5
Share_institution (Omitted)	124	21.037	12.437	0	56.8
Share_other	124	5.668	3.849	0	18.2

The size of the entrepreneurial cluster: As an index of the size of the local entrepreneurial cluster we used the number of entrepreneurs in the 35 miles radius from the academic institution in question. This information was gathered from Linkedin data. In order to prevent causality problems we excluded the number of the institution's spin-offs in this index we use in regressions. Table 3a group this variable to three groups and present descriptive statistic regarding these groupings.

Table 3a: Cluster Size and Institution spin-offs - Descriptive Statistics

Cluster Group	Cluster Size	% from Institution	T. Spin-offs	% Local	Institution Rank
Small Clusters	59.8	24%	59.6	21%	32.2
Mid Clusters	521.4	5%	66.3	39%	34.4
Large Clusters	7709.0	2%	184.7	54%	60.2

[3] We want to Thank Saul Lach and Mark Schankerman for letting us use their data on royalties share policy.

Venture capital availability: As an index of the venture capital availability in different locations, we counted the number of venture capital partners in the 35 miles radius from the academic institution in question. This information was also gathered from Linkedin data.

University Ranking: As an index of university reputation we used the academic rating score of U.S. News rank colleges and universities for the year 2009 (U.S. News & World Report, 2009). We used the score for the entire university, the average score of the leading technology departments and of the business school score. Table 3b group this variable to three groups and present descriptive statistic regarding these groupings.

Table 3b: Institution rank and spin-offs - Descriptive Statistics

Institution	Cluster Size	T. Spin-offs	% Local spin	Institution Rank	MBA Rank
Low Rank	1390.7	38.9	33%	8.4	2.7
Mid Rank	2187.3	79.6	38%	44.5	20.7
High Rank	4671.6	191.7	44%	73.7	59.3

R&D expenditure: R&D expenditure data was collected from AUTM database for each institution. As a proxy to the commercial orientation of university research increased we used the sources of R&D finance (following Di Gregorio and Shane, 2003). This data was gathered from WebCaspar site.

Complementarily between different TLO's instruments: In order to evaluate the complementarily effect of the strength of the TLO licensing activity on the rate of spin-off formation, we collected data on the number of licenses and the revenues generated from licenses in the university. Both figures are reported by the AUTM annual reports[4].

Institution size: the number of faculty members, should have significant impact on the spin-off rate. This information was gathered from the National Center for Education Statistics (The Integrated Postsecondary Education Data System (IPEDS)).

[4] Gregorio and Shane (2003) suggested that both variables can be used as control variables. Licenses and option agreements capture the production of technology that is of interest to the private sector. As a result, using this control for inventive output, we capture only idea that has commercial potential. By controlling for revenues generated data we can control for inventions with significant commercial potential that can justify start-up creation.

Tables 4 provide a correlation matrix for the variables used in the regression. There is a strong correlation between the number of entrepreneurs and the number of VC partners in a cluster; therefore we do not use these variables together in the regressions. There is also a strong correlation between the ranks of the different scientific departments thus we do not use them together in a regression and instead we use their average score. Similarly, we see that R&D expenditure is highly correlated to the average rank of the technological departments; therefore we do not use them together in the regression. Finally, there is very high correlation between the different performance indexes of the TLOs, therefore we use only the aggregate license' revenues. In the other variables used in the regressions there is no evidence of strong multicolinearity.

Table 4: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. Spin_35m	1.000													
2. N_local_spin	0.794	1.000												
3. FT_eq	0.274	0.330	1.000											
4. RD_exp	0.516	0.585	0.455	1.000										
5. Univ_score	0.485	0.475	0.249	0.566	1.000									
6. MBA_score	0.550	0.538	0.367	0.498	0.693	1.000								
7. Tech_score	0.582	0.589	0.460	0.772	0.774	0.693	1.000							
8. Cluster 35	0.481	0.218	-0.031	0.153	0.332	0.189	0.254	1.000						
9. VC_partners	0.571	0.298	0.003	0.169	0.333	0.220	0.272	0.964	1.000					
10. license_per	0.133	0.041	0.167	0.056	0.198	0.264	0.121	0.291	0.328	1.000				
11. %_federal	0.351	0.242	-0.080	0.200	0.295	0.227	0.273	0.299	0.283	0.094	1.000			
12. %_local	-0.260	-0.193	0.090	-0.196	-0.340	-0.280	-0.224	-0.277	-0.261	-0.092	-0.601	1.000		
13. %_industry	0.043	-0.026	0.001	-0.016	0.011	0.066	-0.027	-0.048	-0.041	-0.056	-0.128	-0.063	1.000	
14. %_institution	-0.369	-0.252	0.035	-0.182	-0.265	-0.233	-0.270	-0.236	-0.244	-0.112	-0.783	0.200	-0.266	1.000
15. %_other	0.316	0.246	0.234	0.256	0.418	0.358	0.333	0.271	0.312	0.289	0.153	-0.311	0.170	-0.204

Methodology

We are able to discern only that an individual is currently or was previously employed at the parent institution and subsequently founded a new start-up company. We lack precise data on the year the new company was created, prohibiting time series modeling or the specification of a causal model. The data only allow a test of the association between characteristics of the academic institution and the rate of local and non-local spin-off' founders.

The dependent variables in our regressions are the number of faculty members that founded a startup company. Our model is estimated separately for local founders, defined as those within a 35-mile radius of the focal university and all founders. The dependent variable for the local faculty founder regression has a mean of 43.12 and a standard deviation of 75.06. The dependent variable for the non-local faculty founder regression has a mean of 60.10 and a standard deviation of 79.94. These dependent variables are count variables of rare events, banded by zero and the distribution of these variables is over-dispersed, with each standard deviation larger than the corresponding mean. We used as a baseline the Negative Binomial and Poisson regression techniques (as a robustness test we also performed an OCS regression). The Poisson distribution assumes that the mean and variance of the process are equal. This assumption is violated when over-dispersion of the dependent variable is observed. The negative binomial model provides a solution to the problem of a skewed distribution by assuming a gamma distribution for the conditional mean of the dependent count variable and therefore allows the conditional mean and variance to vary (Hilbe, 2007). A goodness-of-fit test partially rejected the Poisson distribution assumption. These results indicate that the negative binomial is the appropriate model to use in the estimation. Assuming unobserved heterogeneity is randomly distributed across corporations and establishments we use a random effect maximum likelihood model (Hausman et al., 1984; Cameron and Trivedi, 1998; Allison and Waterman, 2002).

Table 4: Cluster Size-Institution Rank' Matrix –Total institution spinoffs; and share of founders in the cluster originated from the local academic institution

Total Spin-offs from institution / % of founder from the Institution	**Low Rank**	**Mid Rank**	**High Rank**	**Low Rank**	**Mid Rank**	**High Rank**
Small Clusters	31	69	101	20%	32%	20%
Mid Clusters	33	77	168	6%	7%	9%
Large Clusters	54	93	300	2%	2%	2%

6. Empirical results

Tables 5a-5b and 7a-7b present the empirical results of the Poisson regressions, considering local and non-local faculty spin-offs. Tables 6a-6b and 8a-8b present the empirical results of the Negative Binomial regressions, considering local and non-local faculty spin-offs.

Model 1 in all tables considers the impact of the university rank on the number of spin-offs, controlling for university size. The results indicate that the university quality has a positive and statistically significant effect on spawning. This effect is larger for local spin-offs. These results suggest that higher ranked universities spawn more founders. These results are similar to the findings of Di Gregorio and Shane (2003).

Model 2 in all tables considers the impact of the technology departments' average ranking and the rank of the business school on the number of spin-offs. The results suggest that the rank of the business school has a positive and statistically significant impact on spawning, controlling for technology department average rank (or university rank). The results indicate that universities with high quality technical programs and highly ranked business schools spawn more founders.

Models 3 and 4 in all tables consider the impact of the local cluster (e.g. level of entrepreneurship activity and number VC partners' active in the region of the parent institution) on spawning. The results suggest that both variables have positive and statistically significant impact on spawning. Not surprisingly, this effect is mostly relevant for local academic spin-offs. However, it has some limited impact also on non-local academic spin-offs, probably due to cultural effects of being employed in an institution surrounded by an entrepreneurial cluster.

Models 5 and 6 in all tables consider the impact of the scope and the orientation of the R&D expenditure (e.g. total size of R&D expenditure and the sources of their finance) on spawning. The results suggest that the size of the R&D budget has a positive and statistically significant impact on local and non-local spawning. Moreover, federal-government sponsored R&D has a positive and statistically significant impact on local and non-local spawning. However, industry sponsored R&D has a small positive and statistically significant impact on local spawning, and negative impact on non-local spawning. A small positive and marginally significant impact exists also with local government sponsored research. These results are similar to the findings of Di Gregorio and Shane (2003). These effects are smaller and less significant for non-local spin-offs.

Models 7 and 8 in all tables consider the impact of the effectiveness of the TLO measured by the license' revenues per R&D expenditure (in model 8 we also control for the royalties' share policy of the institution). The results suggest that more effective the TLO is in licensing, the lower the rate of spawning of the institution. These results are statistically significant. This suggests effective TLOs actually lower the incentives of researchers to create a spin-off. The royalities' share policy has a positive and significant impact on local and non-local spawning.

Tables 5a: Poisson estimation of local faculty spawning – Models 1-4

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	4.4E-5*	2.8E-6	-4.8E-6*	3.3E-6	8.6E-6†	3.5E-6	6.5E-6‡	3.5E-6
Univ_Score	0.0310*	0.0006	-	-	-	-	-	-
Tech_Score	-	-	0.0286*	0.0009	0.0214*	0.0009	0.0210*	0.0009
MBA_score	-	-	0.0112*	0.0006	0.0102*	0.0006	0.0094*	0.0006
Cluster_35M	-	-	-	-	0.0001*	2.0E-6	-	-
VC_Partners	-	-	-	-	-	-	0.0013*	4.4E-5
Constant	1.7117*	0.0423	2.0203*	0.0388	2.0684*	0.04	2.1575*	0.04
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.4761		0.6228		0.6947		0.7060	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 5b: Poisson estimation of local faculty spawning – Models 5-8

	Model 5		Model 6		Model 7		Model 8	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	1.9E-5*	3.2E-6	2.8E-5*	3.4E-6	3.0E-5*	3.3E-6	3.3E-5*	3.4E-6
Tech_score	-	-	-	-	-	-	-	-
MBA_score	0.0145*	0.0005	0.0125*	0.0005	0.0126*	0.0016	0.0122*	0.0005
VC_Partners	0.0015*	4.2E-5	0.0012*	4.7E-5	0.0013*	4.8E-5	0.0014*	5.2E-5
R&D_Exp	1.2E-9*	5.0E-1	9.0E-10*	4.9E-11	7.9E-10*	5.1E-11	7.9E-10*	5.1E-11
%Federal	-	-	0.0287*	0.0016	0.0281*	0.0016	0.0268*	0.0016
%Local_Gov	-	-	0.0055	0.0040	0.0056	0.0040	0.0061	0.0040
%Industry	-	-	0.0215*	0.0025	0.0194*	0.0026	0.0179*	0.0026
%Other	-	-	0.0157*	0.0041	0.0250*	0.0043	0.0303*	0.0044
Licenses_per	-	-	-	-	-0.5581*	0.0726	-0.6039*	0.0728
Rayolities_S	-	-	-	-	-	-	0.5588*	0.1112
Constant	2.3089*	0.0341	0.3502†	0.1393	0.3702*	0.1384	0.1561	0.1450
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.6980		0.7536		0.7610		0.7638	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 6a: Negative Binomial estimation of local faculty spawning – Models 1-4

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	6.7E-5*	2.4E-5	-8.8E-7	2.1E-5	1.8E-5	2.0E-5	1.6E-5	2.0E-5
Univ_Score	0.0234*	0.0028	-	-	-	-	-	-
Tech_Score	-	-	0.0297*	0.0042	0.2407*	0.0042	0.0238*	0.0041
MBA_score	-	-	0.0078*	0.0027	0.0066*	0.0025	0.0066*	0.0025
Cluster_35M	-	-	-	-	6.6E-5*	1.8E-5	-	-
VC_Partners	-	-	-	-	-	-	0.0016*	0.0004
Constant	1.9543*	0.1864	2.1110*	0.1508	1.9813*	0.1453	2.0252*	0.1433
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.0687		0.1059		0.1195		0.1201	
Alpha	0.8159		0.5805		0.5043		0.5002	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 6b: Negative Binomial estimation of local faculty spawning – Models 5-8

	Model 5		Model 6		Model 7		Model 8	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	2.5E-5	2.1E-5	5.0E-5†	2.1E-5	5.2E-5†	2.1E-5	5.3E-5*	2.1E-5
Tech_score	-	-	-	-	-	-	-	-
MBA_score	0.0113*	0.0023	0.0083*	0.0023	0.0087*	0.0023	0.0083*	0.0023
VC_Partners	0.0020*	4.2E-04	0.0014*	3.8E-4	0.0015*	0.0004	0.0016*	0.0004
R&D_Exp	1.5E-09*	4.0E-10	1.1E-9*	3.7E-10	1.1E-9*	3.7E-10	1.1E-9*	3.7E-10
% Federal	-	-	0.0237*	0.0064	0.0237*	0.0063	0.0230*	0.0063
% Local_Gov	-	-	-0.0047	0.0118	-0.0047	0.0117	-0.0040	0.0117
% Industry	-	-	0.0125	0.0120	0.0120	0.0120	0.0118	0.0119
% Other	-	-	0.0272	0.0204	0.0292	0.0205	0.0316	0.0206
Licenses_per	-	-	-	-	-0.4834	0.5034	-0.4651	0.5350
Royalities_S	-	-	-	-	-	-	0.4795	0.4807
Constant	2.2240*	0.1466	0.6102	0.5024	0.6036	0.5007	0.4136	0.5350
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.1076		0.1268		0.1275		0.1284	
Alpha	0.5655		0.4667		0.4630		0.4587	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 7a: Poisson estimation of non-local faculty spawning – Models 1-4

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	5.2E-5*	2.4E-6	1.5E-05*	2.7E-06	1.6E-5*	2.8E-	1.7E-5*	2.8E-6
Univ_Score	0.0208*	0.0005	-	-	-	-	-	-
Tech_Score	-	-	0.2116*	0.0007	0.0208*	0.0007	0.0200*	0.0007
MBA_score	-	-	0.0072*	4.6E- 4	0.0071*	0.0005	0.0068*	0.0005
Cluster_35M	-	-	-	-	4.3E-6†	2.1E-6	-	-
VC_Partners	-	-	-	-	-	-	0.0002*	0.0004
Constant	2.6146*	0.0318	2.8107*	0.0292	2.8097*	0.0291	2.7632*	2.8767
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.3909		0.5096		0.5100		0.5139	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 7b: Poisson estimation of non-local faculty spawning – Models 5-8

	Model 5		Model 6		Model 7		Model 8	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	2.2E-5*	2.7E-6	2.5E-5*	2.8E-6	2.8E-5*	2.8E-6	3.4E-5*	2.8E-6
Tech_score	-	-	-	-	-	-	-	-
MBA_score	0.0117*	0.0004	0.0119*	0.0004	0.0121*	0.0004	0.0109*	0.0004
VC_Partners	0.0004*	4.5E-5	0.0003*	4.9E-5	0.0005*	4.9E-5	0.0007*	5.2E-5
R&D_Exp	1.3E-9*	3.9E-11	1.2E-9*	4.1E-11	1.2E-9*	4.2E-11	1.2E-9*	4.2E-11
% Federal	-	-	0.0098*	0.0012	0.0096*	0.0012	0.0069*	0.0012
% Local_Gov	-	-	0.0090*	0.0026	0.0089*	0.0026	0.0098*	0.0026
% Industry	-	-	0.0006	0.0021	-0.0012	0.0021	-0.0053†	0.0022
% Other	-	-	-0.0044	0.0035	0.0007	0.0036	0.0148	0.0036
Licenses_per	-	-	-	-	-0.7644*	0.0902	-0.8168*	0.0879
Royalities_S	-	-	-	-			1.4150*	0.0837
Constant	2.9611*	0.0270	2.3209*	0.0992	2.3369*	0.0988	2.3369*	0.0988
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.5285		0.5375		0.5475		0.5769	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 8a: Negative Binomial estimation of non-local faculty spawning – Models 1-4

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	7.8E-5*	1.9E-5	4.8E-5*	1.7E-5	4.3E-5†	1.7E-5	4.6E-5*	1.7E-5
Univ_Score	0.0184*	0.0025	-	-	-	-	-	-
Tech_Score	-	-	0.0208*	0.0037	0.0224*	0.0039	0.0215*	0.0039
MBA_score	-	-	0.0054†	0.0026	0.0058†	0.0026	0.0056†	0.0026
Cluster_35M	-	-	-	-	-2.1E-5	1.5E-5	-	-
VC_Partners	-	-	-	-	-	-	-0.0002	0.0004
Constant	2.5454*	0.1587	2.6490*	0.1374	2.6700*	0.1373	2.6530*	0.1374
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.0605		0.0834		0.0849		0.0836	
Alpha	0.5881		0.4747		0.4687		0.4738	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

Tables 8b: Negative Binomial estimation of non-local faculty spawning – Models 5-8

	Model 5		Model 6		Model 7		Model 8	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
FT_eq	4.5E-5†	1.8E-5	5.6E-5*	1.9E-5	5.8E-5*	1.9E-5	5.8E-5*	1.9E-5
Tech_score	-	-	-	-	-	-	-	-
MBA_score	0.0091*	0.0023	0.0083*	0.0024	0.0087*	0.0024	0.0079*	0.0025
VC_Partners	4.3E-5	3.5E-4	-1.2E-4	3.5E-4	-5.5E-6	3.7E-4	0.0001	0.0004
R&D_Exp	1.7E-9*	3.7E-10	1.6E-9*	3.7E-10	1.6E-9*	3.7E-10	1.5E-9*	3.7E-10
%Federal	-	-	0.0065	0.0057	0.0063	0.0057	0.0061	0.0057
%Local_Gov	-	-	-0.0062	0.0111	-0.0060	0.0111	-0.0040	0.0111
%Industry	-	-	-0.0186‡	0.0113	-0.0195‡	0.0112	-0.0199‡	0.0111
%Other	-	-	-0.0022	0.0205	0.0015	0.0207	0.0078	0.0211
Licenses_per	-	-	-	-	-0.6319	0.5035	-0.6455	0.5038
Royalities_S	-	-	-	-	-	-	0.6770	0.4675
Constant	2.8258*	0.1324	2.5634*	0.4635	2.5623*	0.4619	2.2422*	0.5099
Observations	124		124		124		124	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.0793		0.0845		0.0855		0.0872	
Alpha	0.4913		0.4688		0.4637		0.4554	

* Significant under 0.01; † Significant under 0.05; ‡ Significant under 0.1;

7. Conclusion and Discussion

Regional entrepreneurial cluster development policies have become widely used by policy makers all over the world. One common government initiatives in the early stages of such cluster development process is strengthening the local academic institutions. Research universities provide scientific knowledge, technical information, and skilled workers—the basic raw material for local high-technology clusters (Raymond, 1996; Florida, 2002). One means of enhance these benefits is through creation of spin-off companies (Clayman and Holbrook, 2003). For example, graduate student startups and faculty member spin-offs were part of the development of Silicon Valley's successful high tech cluster (Saxenian, 1994; Zagnoli, 1991).

The objective of this paper is to bring new evidence to the analysis of academic spawning. We provide a unique data source of the number of founders who were previously employed at one of the 124 U.S. academic institutions in our sample, based on the professional social networking site Linkedin and data from AUTM.

Accordingly, spawning is a function of university ranking, the business school ranking and R&D expenditures, after controlling for institution size. In addition, academic spawning is a function of the entrepreneurial and venture capital activity in the region where the academic institution is located. Finally, the effectiveness of the university licensing activity has a negative impact on spawning.

The paper's main policy implications for the academic institutions are that high quality technological faculties are not enough to facilitate academic entrepreneurship; rather a strong entrepreneurial business school is also required. Moreover, the institutions must understand the tradeoff between licensing activity and spin-off activity. The broader implication of this study for policymakers suggests that simply strengthening the academic institutions in the region would not be efficient for knowledge-based regional development, rather a dual focus strategy should be used – both strengthening the local academic institutions and increasing the absorptive capacity of the region for ideas originated from the local academic institutions and creating a more entrepreneurial culture that can support local academic spin-offs.

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